

## REMARKS

This is a response to the Office Action mailed October 30, 2003 in relation to the above-identified patent application.

### **Page 2, #1: Objections to the Specification**

The Examiner made objections to the specification as not explicitly identifying which particular elements of the instant invention are to be taken as being spatial birefringent elements.

It is respectfully submitted that paragraphs [0054] and [0055] of the specification explicitly identifies which particular elements of the instant invention are used to construct an exemplary spatial birefringent element.

The birefringent effect is a phenomenon that when an optical beam propagates through a birefringent element, there is a difference between the optical path lengths (optical path length is the product of the physical path length and the index of refraction) for the optical beam's two orthogonally polarized components. The optical path length difference manifests itself to a phase delay between the two optical components – it is called as “birefringent phase delay” or simply as “phase delay.”

The two orthogonal polarization directions are specific for a birefringent element and they cannot be arbitrary. The birefringent effect is strictly defined as above for the existence of optical path length difference (i.e., phase delay) between two optical components of specified orthogonal polarization directions in a birefringent element. If one or both optical components (of orthogonal polarization directions) experience additional optical effect in addition to the optical path length difference between the two components, such as another birefringent effect, in their propagation through a concerned apparatus, the apparatus does not provide a “bi-refractive” effect and the apparatus is not a bi-refractive element.

As explained in paragraphs [0054] and [0055] of the specification, a spatial birefringent element achieves the birefringent effect in the following way: an input optical beam is separated into two dislocated, i.e., spatially separated, components of orthogonal polarization directions, and the two components are recombined again after they experienced different optical path lengths. The different optical path lengths are obtained when the two beams are spatially separated in a spatial birefringent element.

In comparison, a conventional birefringent element, such as a birefringent crystal, achieves the birefringent effect (i.e., different optical path lengths or a phase delay between two specified orthogonally polarized components) by providing different index of refraction to the two components of orthogonal polarization directions. In conventional birefringent element, the two components of orthogonal polarization directions propagate along the same physical path and there is no spatial separation between the two components when the different optical path lengths (birefringent effect) are obtained.

The difference between a conventional birefringent element and a spatial birefringent element are further illustrated by a figure shown at the end of this “Remarks”.

In Fig. 1 of present patent application, when two input optical beams propagate from location 3 to location 10, elements 19a, 22a, 15a, 23a, and 14a work together as a spatial birefringent element and provide birefringent effect to each of the two input optical beams, respectively. For one input optical beam at location 3, the polarization beam splitter (PBS) 19a separates this optical beam into two orthogonally polarized optical beams (let’s call them **A** and **B**, respectively). Since distances  $L_1$  and  $L_2$  are different (see Fig. 1), optical path length difference (i.e., the birefringent effect) is obtained when **A** of one polarization direction propagates through (19a, 22a, 15a, 22a, 19a) and **B** of the other (orthogonal) polarization direction propagates through (19a, 23a, 14a, 23a, 19a) to location 10. At location 10, **A** and **B** are recombined to form one optical beam again as it was the case at location 3. The birefringent effect is obtained by spatially separating the optical components of orthogonal polarization directions and then combining them – thus, it is called “spatial birefringent element”.

Similarly, when optical beams propagate from location 12 to location 19, elements 19b, 21b, 15b, 23b, and 14b work together as a spatial birefringent element and provide the birefringent effect. When optical beams propagate from location 24 to location 31, elements 19b, 22b, 15b, 24b, and 14b work together as a spatial birefringent element and provide the birefringent effect. When optical beams propagate from location 33 to location 40, elements 19a, 21a, 15a, 24a, and 14a work together as a spatial birefringent element and provide the birefringent effect.

**Page 2, #2:**

The Examiner made objections to the claims as not explicitly setting out which variable is to be associated with said recited “phase delays.”

It is respectfully submitted that phase delay is not necessarily associated with a specific variable in the claims. For example, in claims 9 and 11, the phase delays are  $\Gamma$  and  $2\Gamma$ . In claim 20, the phase delays are selected from the variables listed in Table I (e.g,  $\Gamma+2m_1\pi$ ,  $2\Gamma+2m_2\pi$ , etc.). Detailed descriptions on phase delays can be found in the specification [66], [71], [79], [84], [90], [97], [98], [107], [115-118], etc.

It is respectfully requested that no modification is required.

**Page 3, #3:**

Claim 15 is rejected under 35 U.S.C. 112.

Claim 15 has been amended to have proper antecedent support in the specification. “interleaved channels” is replaced by “interleaver channels” in amended claim 15. Paragraph [0019] in the specification discussed interleaver channel spacing. [...narrower interleaver channel spacing facilitates enhanced bandwidth utilization and an desirably increased number of channel counts.]

**Page 3, #4:**

Claims 1, 3, 4, 6-8, 10, 12-14, 16-18, and 21 are rejected under 35 U.S.C. 102 (e) as being anticipate by Chang et al (6,335,830)

It is respectful to submit that none of the elements (include 400, 492, 490) in Fig. 4a and other figures of Chang (6,335,830) is “spatial birefringent elements.”

400 is not a spatial birefringent element because, at the exit of 400, the two separated beams are not recombined to generate the birefringent effect. At the input of 492 and 490, there are two separate input beams. The combination of 400, 492, 490 is not a spatial birefringent element either since during the beams’ propagation, they experienced additional birefringent effects at elements 424 and 426, rather than a simple optical path length difference between the two orthogonally polarized compoments. Elements 400, 492, 490 are “spatial separators” or “spatial recombiners” for optical beams, which are the same elements 10 and 11 (beam displacers) of present patent application (see Fig. 1).

If two optical components of orthogonal polarization directions are separated and go through different optical path lengths, but they never recombine again, there is no birefringent effect between the two components. If they do recombine, but one or both of them experience additional optical effect (in addition to the only optical path length difference), there is no birefringent effect either.

A birefringent effect can be realized by conventional birefringent crystals such as element 424 and 426 in Fig. 4a of Chang (6,335,830). A birefringent effect also can be realized by spatial birefringent elements (such as the one made of elements 19a, 22a, 15a, 23a, and 14a in Fig. 1) as described in this patent application. Comparing Fig. 1 of this patent application and Fig. 4a of Chang's, a spatial birefringent element (such as the one made of elements 19a, 22a, 15a, 23a, and 14a in Fig. 1 of this application) is functionally equivalent to a birefringent crystal (such as 424 or 426 in Fig. 4a of Chang's). The spatial birefringent elements and conventional birefringent elements are two completely different technologies. This invention of using spatial birefringent elements to construct an interleaver eliminates the use of expensive conventional birefringent crystals.

Independent claims 1, 16, 18 and 21 have been amended to clearly define "spatial birefringent element" in the claims in addition to the definition and description in the specification.

Claim 13 has been amended per examiner's suggestion.

Claims 3, 4, 6, and 17 are canceled without prejudice.

Thus, it is respectful to request that independent claim 1 (amended) and its dependent claims 7, 8, 10, 12, 13 (amended), and 14; independent claims 16 (amended), 18 (amended) and 21 (amended) are allowable.

**Page 6, #5:**

Claims 2, 5, and 19 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Chang et al (6,335,830) in view of admitted prior art.

It is respectful to submit that cited reference of Chang (6,335,830) teaches an apparatus or a method to use conventional birefringent crystal, such as 424 and 426 in Figure 4, to construct an interleaver. The present application discloses a new technology using spatial birefringent element that is fundamentally different with the cited reference. None of the

elements in the cited reference (Chang's 6,335,830) is spatial birefringent element per definition and description in the specification of present application.

Claim 2 is a dependent claim on claim 1. Independent claims 1 have been amended to clearly define "spatial birefringent element" in the claim in addition to the definition and description in the specification.

Claims 5 and 19 are canceled without prejudice.

Thus, it is respectful to request that claim 2 (amended) is allowable.

**Page 7, #6:**

Claims 9, 11, and 20 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Chang et al (6, 335, 830).

It is respectful to submit that cited reference of Chang (6,335,830) teaches an apparatus or a method to use conventional birefringent crystal, such as 424 and 426 in Figure 4, to construct an interleaver. The present application discloses a new technology using spatial birefringent element that is fundamentally different with the cited reference. None of the elements in the cited reference (Chang's 6,335,830) is spatial birefringent element per definition and description in the specification of present application.

Claims 9 and 11 are dependent claims on claim 1. Independent claim 1 has been amended to clearly define "spatial birefringent element" in the claim in addition to the definition and description in the specification.

Independent claim 20 has been amended to clearly define "spatial birefringent element" in addition to the definition in the specification.

Thus, it is respectful to request that independent claim 9, 11, and 20 (amended) are allowable.

**Page 8, #7**

Claim 15 is rejected under 35 U.S.C. 103 (a) as being unpatentable over Chang et al (6, 335, 830) in view of Lahat et al. (6,417,944).

It is respectful to submit that cited reference of Chang (6,335,830) teaches an apparatus or a method to use conventional birefringent crystal, such as 424 and 426 in Figure 4, to construct an interleaver. The present application discloses a new technology using spatial

birefringent element that is fundamentally different with the cited reference. None of the elements in the cited reference (Chang's 6,335,830) is spatial birefringent element per definition and description in the specification of present application.

It is respectful to submit that Chang's patent actually cannot provide tunable channel spacing due to its inherent limitation. The channel spacing is determined by the (birefringence) phase delay (e.g.,  $\Gamma$ ) of the first birefringent element in an interleaver. In Chang's apparatus, the channel spacing is determined by the phase delay of 424 (Fig. 4a) and 424 is a birefringent crystal. The phase delay in a birefringent crystal is fixed and is not tunable. Thus, the channel spacing is fixed in Chang's apparatus.

In comparison, this application discloses an interleaver using spatial birefringent elements, where the birefringent phase delay can be changed. For example, by changing the relative positions of 15a and/or 14a, distances  $L_1$  and/or  $L_2$  (see Fig. 4) are changed. As a consequence, the spatial birefringent phase delay is changed and thus the channel spacing is tuned in this invention. Another tuning method is to have liquids of different refractive index in the spacing between 19a and 14a (and/or in the spacing between 19a and 15a) to change the birefringence phase delay in order to achieve tunable channel spacing.

Chang's patent cannot provide the channel spacing tuning capability as the instant application can. Thus, it is respectful to request that claim 15 is allowable.

#### **Page 9, #8: Double Patenting Rejection**

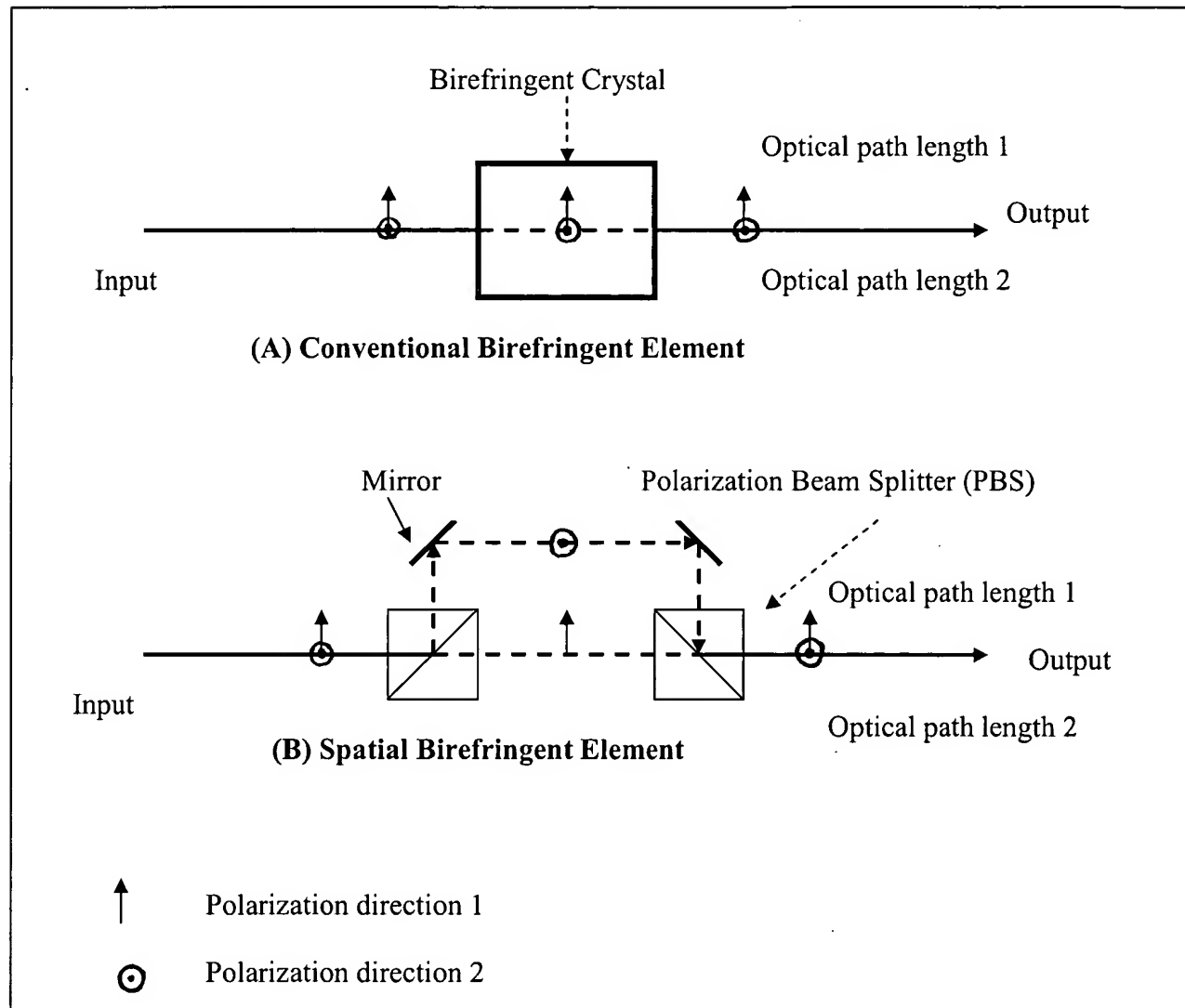
A terminal disclaimer which disclaims the terminal portion of any patent issuing on the subject patent application that extends beyond the termination of any patent issuing upon U.S. application serial no. 09/891,795 and which requires co-ownership of such patents is provided herewith to obviate the double patenting rejection of the subject patent application.

#### **Further Note on Spatial Birefringent Element**

Conventional birefringent crystal and spatial birefringent element are two different types of technology. The following figure are exemplary diagrams illustrating their different working principle.

In the upper part of the figure (A), an optical input beam propagates through a conventional birefringent element (e.g, a birefringent crystal). Birefringent effect (phase delay)

is obtained for two orthogonally polarized optical components without physical or spatial separation of the two components as they pass through the birefringent element. The birefringent effect (phase delay) is inherently provided to the two components by the birefringent crystal.



Comparison between conventional birefringent element/crystal and spatial birefringent element.

In the lower part of the figure (B) for a spatial birefringent element, an optical input beam is first separated into two orthogonally polarized components (e.g., by a polarization beam splitter - PBS). Each component propagates through a different physical route, which are spatially separated. Then, the two components are recombined (e.g., by another PBS). In a



spatial birefringent element, the birefringent effect (phase delay between the two components) is obtained by having the two optical components travel with different optical path lengths before they are recombined.

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